THE METALLIC COLORS OF FEATHERS FROM THE NECK OF THE DOMESTIC PIGEON.

R. M. STRONG.

The so-called metallic colors and iridescent effects exhibited by many feathers have been variously explained by different writers. In general they are recognized as diffraction phenomena peculiar to the barbules.

If one observes the neck of a gray domestic pigeon by reflected sunlight, the feathers on the sides will appear bright metallic-green when the angles of incidence and reflection are small. But when the angles are large, the same region has a purplish appearance. Under other conditions a dull brown color prevails. A single feather gives metallic colors only from the distal exposed portion.

The hypotheses based on the supposed presence of striæ or ridges, supported by Haecker ('90) and others are seen at once to be inapplicable to this case when one finds that the feather may be rotated through a whole circle with essentially the same color effects for given angles even from individual barbules. Furthermore, a careful microscopic study of the barbule surface shows that irregularities such as striæ, ridges, pits, knob-like elevations, etc., are not frequent enough when sufficiently small to produce grating effects, and in fact are not normal occurrences.

On comparing barbules giving metallic colors with barbules from the same barb in a region of non-metallic colors, striking modifications are found. The barbules from the region where metallic colors do not appear are of the typical form, with a proximal flattened region, a longer attenuated portion, and well-developed barbicels on the distal barbules. They present their dorsal margins upward in a dorsal view. There is a comparatively sparse pigmentation with the typical rod-shaped granules of melanin found in feathers.

In the region of metallic colors, one finds the proximal barbules essentially like the distal barbules and flattened throughout their extent. The attenuated portions characteristic of typical

barbules are absent as are also the barbicels. There is a very heavy dark pigmentation of the dorsal halves of the barbules and they are arranged so that they present their flattened surfaces upward in a dorsal view. The dorsal margins rest upon the median regions of the next more distal barbules and the ventral margins are thereby hidden from view. The arrangement suggests, somewhat, two rows of shingles overlapping each other on either side of a median axis.

On sectioning these barbules, I find an outer transparent layer less than one micron in thickness, which encloses cell cavities more or less closely packed with *spherical* granules of melanin pigment less than one micron in diameter. The greater part of this pigment is in the dorsal half of the barbule, the part visible in a dorsal view of the feather.

For several months I held strongly to the view that the thin transparent layer produced the well-known interference colors of thin plates, as was supposed by Altum ('54, '54a) and Brücke ('61). The exceedingly uniform size and unusual shape of these pigment granules seemed too significant, however, to warrant an unqualified acceptance of the thin-plate hypothesis. Usually, melanin granules become more or less generally fused together into irregular masses or are imbedded in the horn substance of the feather. In the barbules which give metallic colors, however, the spherical granules retain their individual form. Cross sections frequently show them scattered about outside the barbule section and they seem to have been simply packed in the cell cavities of the barbules with little or no cementing substance to hold them together.

In the feather germ, I find typical pigment cells or chromatophores which produce typical rod-shaped granules. But after these granules have passed into the cells composing the fundaments of the barbules which are to have metallic colors, they are transformed into spherical granules.

By a fortunate manipulation of apparatus, recently, I was able to view barbules by strong reflected sunlight while using a Leitz No. 7 objective. A beautiful pattern of gleaming spheres was presented to my eye. Each pigment granule appeared to be diffracting light and all the colors of the spectrum were visible in the field. On the broad surface of the barbule, where the

angles of incidence were small, the predominant colors were yellow and green, especially green. On the margins where the angles of incidence were great, the prevailing colors were reds and purples.

The colors of the feathers described, when observed without a microscope, are very apparently mixed colors. The greenish effects are produced when light strikes the broad surfaces of the barbules and is reflected with a small angle of reflection. The reds appear only when light falls with a large angle of incidence on the pigment granules of a margin or elevated portion of a barbule.

We seem to have a clear case of Newton's rings where each pigment granule comes in contact with the outer transparent layer.

This is a preliminary statement of my results. Another paper describing them in greater detail with the aid of figures is in process of publication.

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